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ABSTRACT

One of a series of sixteen knowledge transformation papers, this paper presents an overview of considerations and methods for accomplishing energy conservation in the schools. First, the National Energy Act of 1978 is outlined with special attention to the school and hospital energy conservation grant program. In the next section on energy management, various programs underway throughout the country are described. An energy audit is recognized as an important part of such management, while life-cycle costing is mentioned as gaining acceptance by administrators. Then, various innovative means of conserving energy are discussed, such as subsurface building design, location consolidation, and heat recovery and storage systems. The major innovation, however, is found to be solar energy, on which much research is being conducted to determine the cost benefits of construction and retrofitting. It is emphasized that for any innovation to be truly effective, consideration must be given to the interaction between people and the environment so that the users' needs are met without discomfort. A brief summary is given of a national energy conference for schools that was held in Washington, D.C., in January, 1979. At the end is an annotated list of resources for the use of school administrators and educational facility planners. (EIG)

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Information Series No. 152

NEW AND RETROFITTED FACILITIES FOR ENERGY CONSERVATION

written by

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Vocational Education

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1979

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FOREWARD

The energy crisis has resulted in a strong national focus on such concerns as energy waste, rising heating and cooling costs, and viable conservation measures. Both public and private buildings are under scrutiny for the sake of improved energy management. Legislation, in the form of the National Energy Act of 1978, reflects the magnitude of the national concern over energy conservation. One of five bills under the National Energy Act, the National Energy Conservation Policy Act, provides funding for schools and hospitals to undergo energy audits and adopt changes in operations and maintenance to reduce energy consumption. The provisions of this Act constitute one of the topics covered in this paper. Other subjects include recommendations for energy management programs in schools, a discussion of innovative means of conserving energy in school facilities, and a listing of energy conservation resources of use to school administrators and facility planners.

"New and Retrofitted Facilities for Energy Conservation" is one of a series of 16 papers produced during the first year of the National Center's knowledge transformation program. The 16 papers are concentrated in the four theme areas emphasized under the National Center Contract: special needs subpopulations, sex fairness, planning, and evaluation in vocational education. The review and synthesis of research in each topic area is intended to communicate knowledge and suggest applications. Papers should be of interest to all vocational educators, including administrators, researchers, federal agency personnel, and the National Center staff.

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THE PROBLEM

Clearly, energy conservation is not the exclusive concern of educators, as the last decade has seen the development of a serious national energy crisis. President Carter's "Energy Address to the Nation" (1977), in calling for the establishment of a national policy on energy conservation, points out that if worldwide consumption of oil and natural gas continues rising at present rates, total worldwide proved reserves will be seriously depleted with the next three or four decades, if some new energy source is not developed. Legislation during the past year reflects the magnitude of national concern over the energy crisis.

Increasing national attention has focused on energy waste, rising heating and cooling costs, and viable energy conservation measures for eliminating wastes and maintaining costs at manageable levels. Buildings, both public and private, are under scrutiny for the sake of improved energy management. Life-cycle costing, solar heating, the use of heat recovery techniques, improved insulation, and retrofitting are among the energy-saving measures being applied to public and private edifices alike.

The schools, with high maintenance costs and dimishing financial resources, have serious reason for energy conservation concern. In a recent report to the U.S. Energy Research and Development Administration, the Educational Facilities Laboratories (EFL) projected that public schools will waste $740 million on energy in the coming year. The EFL also noted that schools could cut energy consumption 20 percent to 30 percent by practicing conservation and another 20 percent by modifying school structures. Eighty-five percent of the 766 schools in the EFL sample could save energy but do not for a variety of reasons, including lack of administrative support, a shortage of trained personnel to operate equipment, insufficient funds for maintenance, and the tendency to purchase equipment with low initial costs but high operating expenses (Phi Delta Kappan, 1978). Sophisticated equipment which is frequently out of adjustment is another problem school personnel are facing in the operation of their heating plants. Recognition of the extent of energy waste in the schools and similar public structures led to federal funding appropriations in March, 1978 and to a clear legislative mandate in the form of school and hospital energy conservation grants in 1979.

RECENT LEGISLATION

The school and hospital energy conservation grants are part of one bill, the National Energy Conservation Policy Act of 1978, which itself is one of five bills under the National Energy Act passed by Congress on October 15, 1978. The five pieces of legislation comprising the National Energy Act are as follows:

1. National Energy Conservation Policy Act of 1978

2. Power Plant and Industrial Fuel Use Act of 1978

3. Public Utilities Regulatory Policy Act

4. Natural Gas Policy Act of 1978

5. Energy Tax of 1978

Specifically, the National Energy Conservation Policy Act of 1978 provides for the following programs: utility conservation for residences; weatherization grants for low income families; a solar energy loan program; energy conservation loan programs; the grant program for schools and hospitals; energy audits for public buildings; appliance efficiency standards; and other provisions, including two grant programs to promote solar fitting of federal facilities (National Energy Act, 1978).

Under the school and hospital energy conservation grant program, over $900 million will be available over the next three years for the improvement of the energy efficiency of schools and hospitals. During FY 1979 alone, $300.5 million are available for energy conservation projects. The U.S. Department of Energy Office of Conservation and Solar Application will administer the grants through state energy agencies. Congress had appropriated $200.4 million for the program in 1978, but the funding was never expended because authorizing legislation had not been enacted (Education Daily, October 20, 1978).

The grant program for schools and hospitals is divided into two phases. During the first phase, states will receive grants from the Department of Energy to conduct preliminary energy audits in appropriate buildings, creating a "building profile" of each eligible facility in terms of type, size, energy use level, and energy using systems. The audits are also intended to identify changes in operation and maintenance to reduce energy consumption without high additional expense and analyze feasibility of retrofitting. This preliminary energy audit is expected to produce recommendations leading to a 10 to 15 percent reduction in energy use in schools and hospitals (Education Daily, November 15, 1978). In many cases, school personnel have already been conducting energy audits or "mini audits" for some time and are familiar with the process.

During the second phase, the Department of Energy will make grants to schools and hospitals for technical assistance programs and energy conservation projects. Eligible schools and hospitals must have had an acceptable energy audit, the recommended operations and maintenance procedures must have been implemented, and the results of the audit must indicate that further major retrofitting would pay back in ten years of less (Education Daily, November 13, 1978).

Grants will go to eligible institutions in accordance with plans developed by the energy office in each state and approved by the Department of Energy. States are required to submit energy plans which include a survey of energy use in eligible facilities, an estimate of energy savings, and the number and type of facilities that may qualify for grants, programs to identify persons qualified

to carry out audits and projects, and a description of procedures the state will follow in allocating funds. Formula grants are awarded to the state energy agencies on the basis of climate, population, and availability of fuel (Education Daily, October 11, 1978).

Schools will receive a minimum of 30 percent of the federal money available, hospitals will also receive 30 percent, and the remaining 40 percent will be distributed on the basis of recommendations by state energy offices. All grants must be matched 50/50 with nonfederal funds, but schools and hospitals can use in-kind contributions such as personnel salaries or building materials on hand for all or part of their 50 percent. New construction is not included in the grant program (Education Daily, November 13, 1978).

Proposed regulations for the implementation of the bill were published on December 12, 1978 (Federal Register 43: 239). According to these regulations, states can make preliminary energy audits of schools and hospitals by contacting individual institutions or randomly sampling institutions grouped according to size. Computerized audits of school buildings by the Public School Energy Conservation Survey (PSECS) will qualify if PSECS I and II or PSECS III are used (Education Daily, December 14, 1978).

ENERGY MANAGEMENT IN THE SCHOOLS

In The Principal and Energy Conservation, Frederickson (1977) comments that schools can achieve significant energy savings by inspecting and upgrading facilities, setting and servicing equipment properly, and changing wasteful habits in energy use. In existing buildings, energy savings strategies can be developed at three levels: (1) programmatic--the education program and school activities; (2) operational management; and (3) physical plant and operating system (Colorado State Department of Education, 1975).

The energy audit or "mini audit," whether conducted by local school personnel or professionals, as in the Educational Facilities Laboratories study, is often the first step in an energy management program. The audit involves analysis of energy use and identification of appropriate conservation measures, which may range from thermostat control to retrofitting. The new school/hospital energy conservation grants will require such audits as first steps in funded energy projects but, as indicated, many schools have already been using them. For example, the Tenneco Corporation recently completed an energy audit on Markham Elementary School in Fairfax County, Virginia, as part of its "Schoolhouse Energy Efficiency Demonstration" (SEED) program. This was the first in a series of demonstrations designed to help schools control rising energy costs by providing cost-effective energy saving suggestions after analyzing the school's energy needs. The audit was requested by the Department of Health Education and Welfare, which runs Markham for children of federal employees. Another energy audit program is run by the American Association of School Administrators (AASA). During the past year, AASA selected ten schools to participate in a one-year comprehensive energy consumption analysis. Engineers are completing a post-modification energy consumption report on one of the schools,

the Washington Elementary School in Kenniwick, Washington. The energy audit program is supported by the federal government, industry, and local school systems (Education Daily, December 11, 1978).

A successful school energy program often entails simple application of management techniques to the problems of conservation, e.g., in boiler adjustments and air intake monitoring. Steps in a workable school energy conservation program as recommended by the Colorado State Department of Education (1975) include the following:

1. The forming of an energy conservation committee within the school district with as many segments of the educational community represented as is practical
2. Assigning of responsibilities to specific individuals, e.g., boiler adjustments for custodial staff
3. Planning for a set of workable guidelines
4. Making an energy audit of each building in the district
5. Establishing evaluation and follow-up procedures to determine the extent to which guidelines are followed

According to the Colorado State Department of Education's publication, An Outline for a District-Level Plan for Energy Conservation (1975), the school district should collect a base amount of data on every school plant, including the following information:

1. Type and amount of each fuel used
2. Amount of electricity used
3. Peak demand level for this electricity

The publication includes a sample energy audit form from the Texas Education Agency and a list of suggestions for reduction of energy use in heating, ventilating, and air conditioning of school facilities.

The Principal and Energy Conservation (1977) also provides guidelines to assist school principals in energy management. The guidelines include among others:

1. Determining the effectiveness and efficiency of building mechanical systems
2. Inspecting caulking, weather stripping and other sealants
3. Closing blinds during extremely cold or hot weather
4. Reducing illumination in the auditorium, cafeteria, and well-traveled hallways
5. Cutting percentage of outside air ventilation to code specifications

The Pennsylvania State Department of Education (1976) has developed a series of recommendations on energy conservation for new and existing school buildings which incorporate architectural and engineering specifications for reduced energy consumption. This useful document also contains suggestions for general operation and maintenance to prevent waste in heating, cooling, and ventilating systems.

Energy Management programs such as those recommended in the documents cited above can yield substantial savings for individual schools or school districts. For example, a program undertaken as a case study at Herricks Union Free School District in New York reduced oil consumption 34 percent and electrical consumption 20 percent. The analysis of energy use in the district showed that large amounts of energy were being used while school buildings were unoccupied. In the senior high school, seven times as much energy was consumed while the building was unoccupied as when it was occupied (Schreiber and Paige, 1976). The costs of modifying the building to improve efficiency of heating and ventilating were paid back in less than one year.

A guidebook produced by the Educational Facilities Laboratories entitled The Economy of Energy Conservation in Educational Facilities (1973, rev. 1978) is perhaps one of the most widely recognized resources for school energy management programs. Among the recommendations included in this document are:

1. A review of school operation and maintenance personnel to determine that they are qualified to operate increasingly sophisticated electrical and mechanical equipment
2. Identification of sources of energy waste
3. Inclusion of energy conservation in construction and modernization programs
4. Use of life-cycle costing in construction decisions

Life-cycle costing, like the energy audit, is being used increasingly by school administrators in their energy management programs. This approach to energy conservation aids administrators in making cost-effective decisions on constructing new or retrofitting existing facilities. The procedure involves determining the cost of construction, operation, and maintenance over the assumed life of a building (Piele and Wright, 1976). Long-range planning of this sort may mean the choice of solar heating or a multipurpose design, which may represent a more costly initial investment but which will represent a savings to the community over a 20- or 30-year period. Careful management and planning, particularly in such long-range facility planning as life-cycle costing, are necessary aspects of an energy conservation program for the entire school district.

INNOVATIVE MEANS OF CONSERVING ENERGY

Whenever it is feasible, schoo' officials are turning to innovative design, particularly solar heating, to reduce energy costs while maintaining the quality of both the educational program and the physical structure of the school. The following is a brief discussion of innovative means of conserving energy in the schools.

Solar Energy

Solar heating and cooling has been a significant focus of the work of the U.S. Energy Research and Development Administration, which predicts that as much as 25 percent of the nation's energy may come from solar technologies by the year 2020 (Hammond, 1975). An early survey of schools in the Northeast by Stein

and Associates architectural firm (1974) concluded that with revised lighting standards, ventilation, building design, and use of solar energy, the schools could operate efficiently at an energy savings of from 25 to 50 percent of the monitored level of use of those sampled in the New York City area. Another early report on an experimental solar heating system in Warrenton, Virginia (Intertechnology Corporation, 1974), showed that solar energy can be used to provide a major portion of a school's energy needs. This study, funded by the National Science Foundation, considered cost benefits, including performance, maintenance, and operational costs.

Still, many of the solar heating designs for schools reported in the literature are experimental and may not reflect true construction or retrofitting and/or operational costs. The cost-benefit ratio is a crucial consideration because returns on solar fitting may be minimal even if the energy savings are significant. Solar technology is advancing rapidly and school administrators need careful guidance from energy experts before deciding to build a new solar heated building or retrofit an older one to accommodate partial use of solar energy. A report by Wood and Warnock (1976) on possible solar retrofitting of a gymnasium, dormitory, classroom-office-laboratory, and office building in Arizona revealed energy savings at a marginal cost benefit. Feasibility of solar heating depends on construction costs, even when life-cycle costing is considered; technology available; availability of other energy sources; climate; and geographic location, among other factors.

Clearly, some techniques represent better investments for schools than others. For example, thermal storage to recycle waste heat has been used in conjunction with the application of solar heating to commercial types of buildings. The solar collector is recommended in retrofitting such buildings only when it becomes cost-effective (Tamblyn, 1977). General Electric has been involved in solar heating and cooling projects in schools, health centers, and commercial buildings. Cohen (1977) reports on General Electric's findings on the potential cost-performance advantages of specific types of solar heat collectors in such buildings. The U.S. National Bureau of Standards (NBS) reports that the cost-effectiveness of solar energy systems depends partly on adjusting the size of the systems to the region in which they are being used. The NBS regards solar heating and cooling as more beneficial for small homes and buildings than for larger or commercial types of buildings (Jacobs, 1977). Solar energy, nevertheless, is being used as a partial heating technique in schools. The Educational Facilities Laboratories has devoted the January, 1977 issue of its newsletter, Schoolhouse, to consideration of the question of whether solar energy is suitable for new or existing schools. The issue contains descriptions of various applications of solar energy schools have installed or are in the process of installing. Examples include a new school with solar energy added, a system of direct heating through glass rooflights, and a system for heating hot water for washrooms and a cafeteria.

Limited use of solar energy, as in a window management program, may represent the most cost-efficient measure for schools which cannot afford new construction or extensive retrofitting. For example, windows can be retrofitted with a louver drape which acts as a solar heat reflector and collector (Rice, 1976). General Electric has developed a window shade which collects and reflects sunlight, saving approximately 40 percent on energy losses through a single-pane

window during winter nighttime, and reducing solar heat gain by about 70 percent during peak power, summer air-conditioning periods (Silverstein, 1977). Reflective venetian blinds can bounce direct beam sunlight onto a white ceiling, allowing for substantial savings on electricity as lighting can be controlled by timed switches or photocells. Beam day-lighting has also been found to be more efficient than the fluorescent lighting favored in school facilities (Rosenfeld and Selkowitz, 1976). At the same time, any window management program designed to reflect or collect sunlight is appropriate only in geographic areas where sunlight is available for most of the year. It represents only one conservation design option of several now available to school facility planners.

Other Conservation Designs

Another energy conservation design for school facilities which is not dependent on the use of sunlight but which involves new building construction is the subsurface building design. Constructing large area facilities underground involves economic savings, conservation of space, and reduction of energy needs (Stauffer, 1977). Subsurface building design has been used successfully in the construction of one elementary school in Reston, Virginia. The school, built under a hill, has a high thermal mass which allows it to act as an energy reservoir, storing heat and delaying the impact of outside temperature changes. The design makes the most of natural phenomena for heating and cooling; the natural earth cover provides insulation (Carter, 1977). Although the approach sounds promising, no effort has been made to develop this experimental design further. It appears that such technology is still too costly and experimental to represent a serious option for most schools.

A variety of other energy conservation designs and measures are now being used in schools. Many vocational facilities recently completed, or under construction, make use of modern technology to save on heating, cooling, and lighting costs. Careful management practices such as scheduling use of overhead doors in shop areas are among ways in which vocational facilities save energy in a practical manner. Multifunctional instructional space, heat recovery and storage systems, air-to-air heat exchangers, low glare lighting at reduced intensity, double sealed overhead doors, and recycling fans are some of the options being used with increased frequency by vocational education facilities planners. Architects are studying the feasibility of using sewage systems as heating sources for new office or school buildings. Where facilities are spread across several buildings with reduced efficiency, administrators are choosing to consolidate into one centralized, energy-efficient location.

Energy conservation measures for schools with limited budgets can be practiced on a level requiring minimal investments into new or retrofitted buildings. Interior lighting design and practices can and should be reevaluated in view of revised standards for acceptable lighting which do not compromise performance or comfort (Ross, 1977). New studies on thermal comfort have revealed factors involved in reducing the need for air-conditioning and mechanical ventilation (Milbank, 1977). According to Hutchinson (1977), procedures used to design ventilation and air flow systems are wasteful. Ventilation rates in many buildings requiring mechanical air flows can be reduced 45-60 percent if

higher humidities are used (Hutchinson, 1977). This fact may be applicable to areas of vocational facilities requiring mechanical ventilation, although safety and comfort should be considered primary in any program designed to reduce ventilation rates. A feature as simple as double pane windows with intermediate dead air space represents a good conservation measure offering both thermal and acoustical insulation. Replacement of nonessential glass with insulated wall space and thermopane tinted glass is another common retrofitting technique used in schools. Tightening seals on windows and doors and recaulking brick structures can also be major sources of fuel savings. Suggestions such as these are made in the various resources available to school administrators and listed in the section entitled "Resources."

Lastly, school administrators and facility planners must rely on careful judgment and sound professional advice when embarking on a program of new construction or retrofitting. The occupants of a school facility--students, teachers, and support staff--must be considered in proposed approaches to energy conservation. Alterations which do not meet the needs of users or cause them discomfort are not productive changes. According to Rubin (1976), tight seals around doors and windows have little usefulness if these are continuously left open and lighting arrangements are wasteful if all lights must be turned on or off at one time. He comments further that technical options for energy conservation require continual sensitivity to the human consequences and the influence of the interaction between people and their environment.

NATIONAL ENERGY CONFERENCE

Growing national concern over the need for schools to be more committed to involvement in the energy crisis led the Department of Energy, the American Vocational Association, and the American Association of Community and Junior Colleges to sponsor a national energy conference in Washington, D.C., January 15-17, 1979. The conference focused specifically on vocational and technical training needed for present and future energy-related occupations. Representatives of business, labor and public interest groups were included in the conference.

The conference covered such issues as the projected demand for skilled manpower in energy-related occupations and training and certification requirements for technicians. Each of the five major energy industries were covered, including petroleum and gas, solar and alternate energy sources, nuclear energy, and coal mining. Model educational programs in energy occupations were presented. An optional session on how to reduce energy consumption in educational facilities was also offered. The program was coordinated under the Education Programs Division of the Department of Energy (AVA Update, Fall, 1978).

RESOURCES

The preceding represents an overview of considerations in and methods for accomplishing energy conservation in the schools. The following is a list of resources including those referred to herein of use to school administrators and educational facility planners. Many of the sources are drawn from the mini-list, "Resources for School Energy Needs," a publication of the Resource and Referral Service funded by the National Institute of Education at the National Center for Research in Vocational Education.

1. Energyline, Environmental Information Center, Inc. (EIC) 292 Madison Ave., New York, NY, 10017. This is a clearinghouse for energy and environmental information. A data base of journal articles, hearings, reports, special studies and other sources is on computer and can be accessed through commercial computer retrieval vendors and other sources.

2. Educational Facilities Laboratories (EFL) 850 Third Avenue, New York, NY 10022. EFL has a major publication in the energy field, The Economy of Energy Conservation in Educational Facilities, known widely as its "little orange book." Originally published in 1973, the pamphlet was revised in 1978. Also available from EFL are Energy and Educational Facilities: Costs and Conservation and Energy Conservation and the Building Shell, as well as Schoolhouse, a free newsletter on school financing, planning, and renovation.

3. U.S. Office of Education Energy and Education Action Center, Suite 514 Reporter's Building, 300 Seventh Street, S.W. Washington, DC 20202. Contact: Wilton Anderson. The Center serves as a clearinghouse on energy and education and can give schools technical assistance on energy standards, projects, and funding sources.

4. U.S. Department of Energy, Education Programs Division, 400 First St., N.W., Washington, D.C. 20545. Contact: Revonda Williams, Program Manager, Vocational Technical Education, Room 307. Information on the recent national energy conference sponsored by this office, the American Vocational Association, and the American Association of Community and Junior Colleges can be obtained through Ms. Williams. Copy of The National Energy Act can be obtained through the Department of Energy Office of Public Affairs, Washington, D.C. 20585.

5. Council of Educational Facilities Planners, International, 29 W. Woodruff Avenue, Columbus, Ohio 43210. Contact: Edmond LeBlanc, Energy Director. A principal publication of this organization is the Energy Sourcebook for Educational Facilities. The council holds a yearly conference, "The Interface," where such issues as the application of energy-conservative use and design of educational facilities are discussed.

6. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), United Engineering Center, 345 East 47th Street, New York, NY, 10017. ASHRAE has a series of publications on energy conservation in existing buildings which includes construction standards necessary as guidelines for school facility retrofitting.

7. American Association of School Administrators (AASA), 1801 North Moore Street, Arlington, VA 22209. AASA has several relevant publications, including School Energy Crisis: Problems and Solutions (1977), Energy Conservation and the Schools (1976), and To Re-Create a School Building (1976).

8. American Institute of Architects (AIA), 1935 New York Ave., N.W. Washington, DC 20006. The AIA has been actively involved in the subject of building design for energy conservation. Its publications include Energy Conservation in Building Design, Energy Conservation in Buildings, and New Design Concepts for Energy Conserving Buildings.

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